Idaho State Department of Agriculture
Division of Agricultural Resources

Ground Water Nitrate Monitoring Near Buhl, Idaho

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ISDA Technical Results Summary #20 April 2004

Introduction

The Idaho State Department of Agriculture (ISDA) currently is conducting follow-up monitoring at Idaho dairy wells with previous nitrate levels above 10 milligrams per liter (mg/L), including a project around the city of Buhl (Figure 1). The project area resides within the Twin Falls nitrate priority area. The objectives of the monitoring are to: (1) characterize ground water quality, primarily related to nitrate-nitrogen (NO_3-N), (2) determine sources of nitrate entering ground water and their relative contributions, (3) relate data to agricultural land use practices, and (4) provide data to support Best Management Practices (BMP) and/ or regulatory decision making and evaluation processes.

The Buhl area monitoring project began in 2001 as a result of seven detections in Twin Falls County exceeding the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) of 10 mg/L for nitrate from ISDA Dairy Bureau testing (Bahr, et. al, 2000). Five of the seven detections exceeding the MCL were at dairies located in the general vicinity of the city of Buhl, Idaho. To establish this project, ISDA selected adjacent domestic wells in the area for testing and re-tested the dairy wells. One out of thirty-one dairy wells re-sampled in 2001 as part of Buhl project exceeded the EPA MCL of 10 mg/L for nitrate. Two out of twenty-five and zero out of twenty-seven dairy wells sampled in 2002 and 2003, respectively, exceeded the EPA MCL for nitrate.

Nutrients, other common ions, and N-15 isotopes were evaluated during ISDA's testing. Laboratory results indicated that the median nitrate concentration of all wells tested was 5.4 mg/L in 2001, 4.5 mg/L in 2002, and 4.7 mg/L in 2003. Monitoring results and evaluations of nitrate sources will assist in recommendations for dairy and farm improvements for ground water protection.

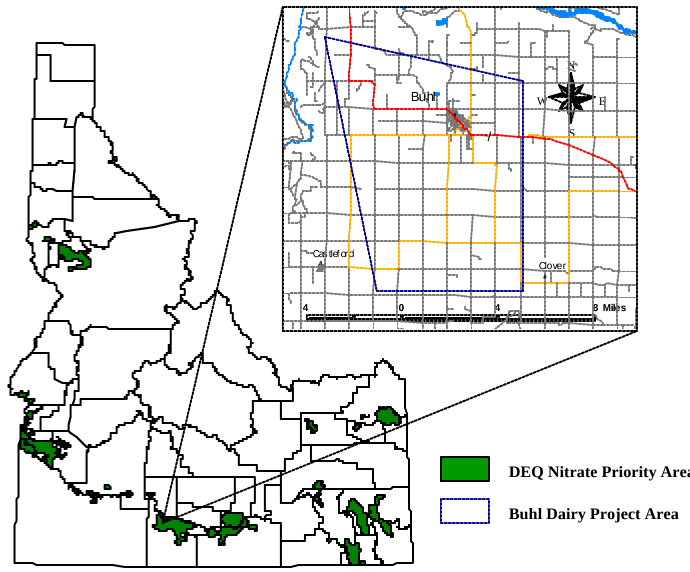


Figure 1. Location of Buhl dairy monitoring project and DEQ nitrate priority areas.

Methods

ISDA selected domestic wells in the area for testing and re-tested the dairy wells. All sampling was conducted after a quality assurance project plan (QAPP) was established. Permission was granted by the land owners prior to sampling.

All sample collection followed the established ISDA QAPP for preservation, handling, storage, and shipping. Field quality assurance/quality control protocols consisted of duplicate samples (at 10% of the sample load) along with blank samples (one set per sampling event). Field blanks consisted of laboratory grade deionized water. The blank samples were used to determine the integrity of the field team's sample handling, the cleanliness of the sample containers, and the accuracy of the laboratory methods. Samples were sent to the University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, Idaho.

Nutrients, common ions, and isotopes were evaluated during ISDA's testing. UIASL conducted tests for nitrate, nitrite, ammonia, alkalinity, orthophosphorus, chloride, sulfate, bromide, and fluoride using EPA Methods 300.0, 310.1, and 350.1. Internal laboratory spikes and duplicates were also completed as part of UIASL's quality assurance program. Isotope samples were collected, frozen, and shipped to the North Carolina State University Stable Isotope Laboratory, in Raleigh, North Carolina for analysis.

Description of Project Area

The Buhl area monitoring project encompasses an approximately 7 mile wide by 10 mile long area of livestock operations and irrigated agricultural land adjacent to the Snake River (Figure 1). The main sources of water for irrigation include diversions from the Snake River, local runoff, and deep wells (Maxwell, 1981). Sprinkler irrigation is the primary local irrigation method. Major crops in the area include alfalfa hay, sugar beets, potatoes, corn, wheat, barley, beans, and oats (Gerhardt, et. al., 2002).

The hydrogeology of the Buhl area consists of an aquifer composed primarily of fractured basalt (Figures 2 and 3). Based on well drillers' reports from dairy wells in the project area, typical depth to ground water is greater than 50 feet below ground level. A few thin clay layers also exist in the area.

Potential sources for nitrate leaching to the ground water in the area include applied nitrogen-based fertilizers, septic systems, cattle manure, legume crops, land application of wastewater, and wastewater lagoons. A potential source of recharge to this shallow system is applied irrigation waters and canal seepage. Ground water flow direction in the sampling area is generally north towards the Snake River (Figure 4).

Results

Sampling results indicate NO_3-N impacts have occurred to the aquifer. Results are summarized and presented in the following sections.

Nitrate

ISDA conducted NO_3-N testing of 54 wells in 2001, 45 in 2002, and 47 in 2003 (Tables 1-3, Figure 5). Results of ground water sampling indicate a maximum concentration of 10.6 mg/L in 2001 (Table 1). The number of wells over the MCL health standard of 10 mg/L was two in 2001 and 2002, and one in 2003. The median nitrate value for all wells was 5.4 mg/L in 2001, 4.5 mg/L in 2002, and 4.7 mg/L in 2003.

Samples obtained only from dairy wells (Table 2) show a decrease in median nitrate value from 6.4 mg/L in 2001 to 5.1 mg/L in 2002 and a slight increase to 5.4 mg/L in 2003. Samples obtained only from domestic wells show a slight decrease in median nitrate value from 3.3 mg/L in 2001 to 2.8 mg/L in 2002 and a slight increase to 3.4 mg/L in 2003 (Table 3).

Median nitrate concentrations have not exhibited large changes over time; however, the percentage of wells over 5 mg/L has decreased from 58.2% in 2001 to 44.2% in 2003 (Table 1). Elevated NO_3-N concentrations near populated areas is of concern because of potential health risks.

Nitrogen Isotopes

The ratio of the common nitrogen isotope ^{14}N to its less abundant counterpart ^{15}N relative to a known standard (denoted $d^{15}N$) can be useful in determining sources of NO_3-N. Common sources of NO_3-N in ground water are applied commercial fertilizers, animal or human waste, precipitation, and organic nitrogen within the soil. Each of these NO_3-N source categories has a potentially distinguishable nitrogen isotopic signature (Table 4). The typical $d^{15}N$ range for fertilizer is $-5\ {}^0/_{00}$ to $+5\ {}^0/_{00}$, while typical values for waste sources are greater than $10\ {}^0/_{00}$. $d^{15}N$ values between $5\ {}^0/_{00}$ and $10\ {}^0/_{00}$ can indicate an organic or mixed source (Kendall and McDonnell, 1998).

Use of nitrogen isotopes as the sole means to determine NO_3-N sources should be done with great care. $d^{15}N$ values in ground water can be complicated by several reactions (e.g., ammonia volatilization, nitrification, denitrification, plant uptake, etc.) that can modify the $d^{15}N$ values (Kendall and McDonnell, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrification very difficult (Kendall and McDonnell, 1998).

ISDA conducted $d^{15}N$ testing at 31 of 54 wells in 2001 and 28 of 45 wells in 2002 to determine potential sources of NO_3-N in the ground water. The 2003 isotope test results are pending.

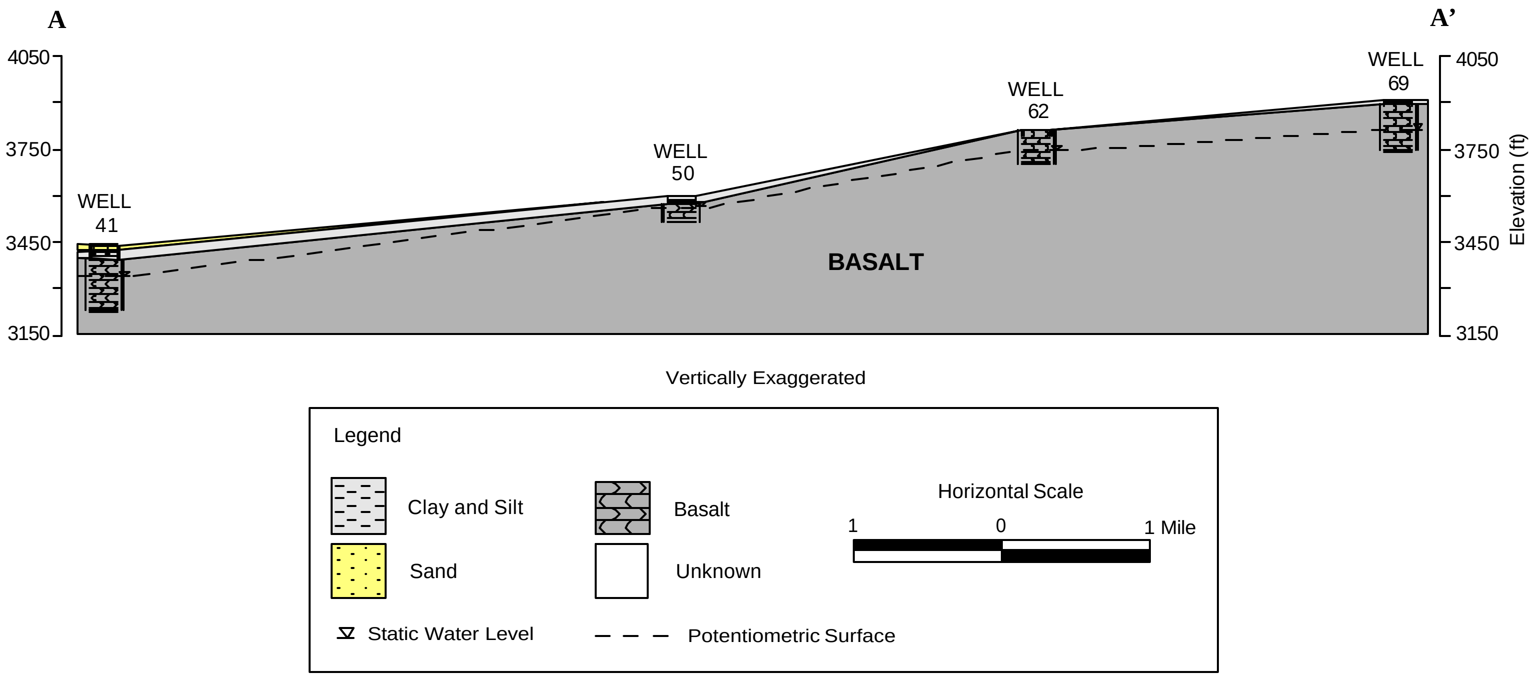


Figure 2. Cross section of basalt aquifer in Buhl area monitoring study. See Figure 3 for cross section location.

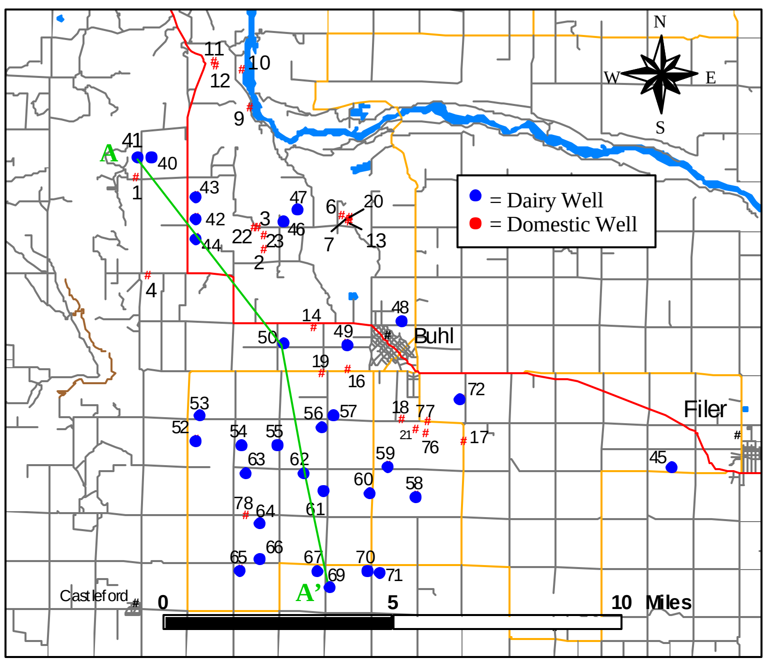


Figure 3. Location and identification numbers of wells sampled by ISDA and cross-section line for Buhl area dairy study

Results of $d^{15}N$ testing returned values that ranged from 4.3 $^0/_{00}$ to 14.3 $^0/_{00}$ in 2001 and 1.5 $^0/_{00}$ to 11.0 $^0/_{00}$ in 2002 (Figure 6). In 2001, two ground water sample sites had values that suggested an animal or human waste source, eight suggested a fertilizer source, and 21 had $d^{15}N$ values that indicated an organic or mixed source of nitrates (Table 4 and Figure 6). Both of the samples that suggested an animal or human waste source in 2001 came from dairy wells west and northwest of Buhl. In 2002, one ground water sample site had a value that suggested an animal or human waste source, 11 suggested a fertilizer source, and 16 had $d^{15}N$ values that indicated an organic or mixed source of nitrates (Table 4 and Figure 6).

Eight of 31 wells (25.8%) had $d^{15}N$ values that suggested a fertilizer source in 2001. In 2002, the percentage increased to 11 of 28 wells (39.3%). The wells suggesting a fertilizer source are located primarily in the irrigated farmland south of Buhl (Figure 6).

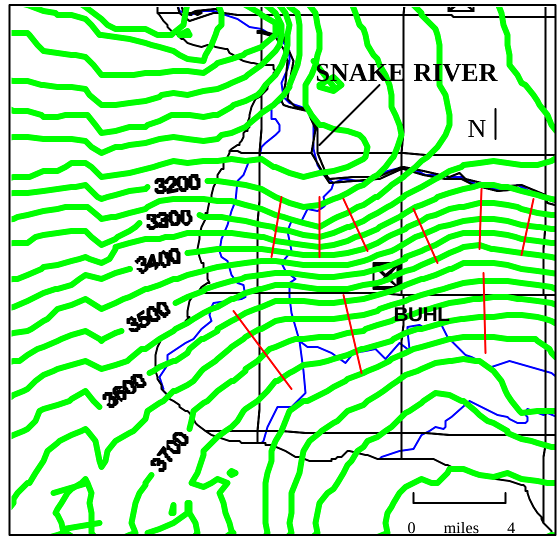


Figure 4. Ground water flow map of Buhl area showing direction of ground water flow (arrows) and equipotential lines (feet above sea level).

Oxygen Isotopes

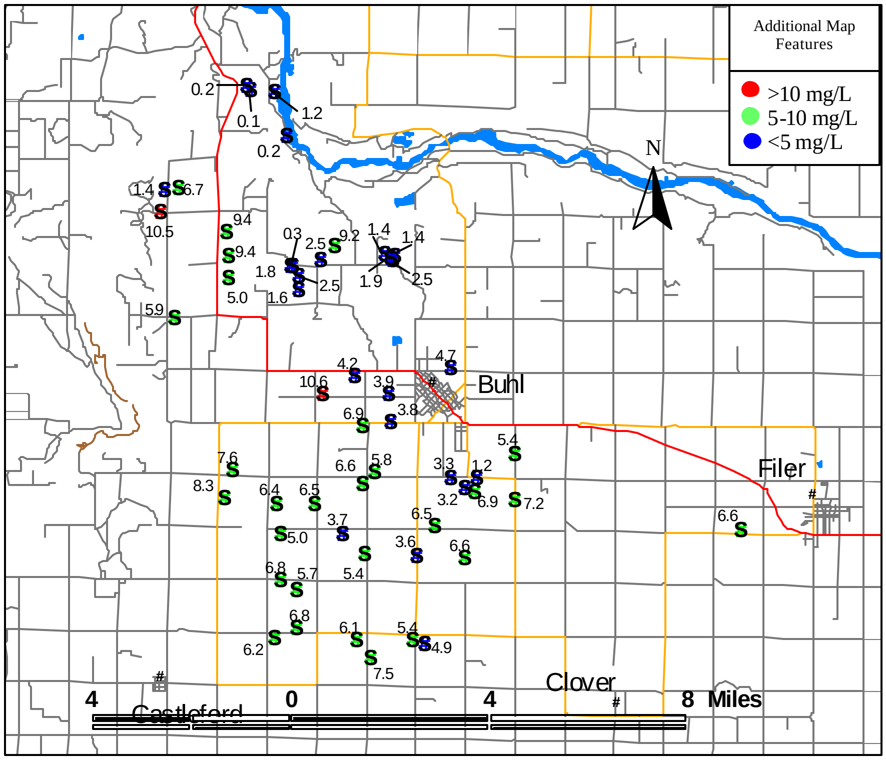
Denitrification is the removal of nitrogen from compounds, by bacteria in the soil, which results in the escape of nitrogen into the air. Analysis of both $d^{18}O$ and $d^{15}N$ of nitrate allows denitrification effects to be distinguished from mixing of sources. Amberger and Schmidt (1987) reported that denitrification results in enrichment in both ^{18}O and ^{15}N of the residual nitrate. This dual isotope approach takes advantage of the observation that the ratio of the enrichment in ^{15}N to the enrichment in ^{18}O in residual nitrate during denitrification appears to be about 2:1 (Amberger and Schmidt, 1987).

Thirty-one wells in the project area that were tested for $d^{15}N$ were also tested for $d^{18}O$ in 2001. An initial analysis of a linear trendline matched to data from a plot of $d^{15}N$ versus $d^{18}O$ (Figure 7) shows approximately a 2:1 ratio, indicating that elevated $d^{15}N$ values are due to denitrification processes. However, the R-squared value (0.05) indicates that the trendline is not reliable. The R-squared value is an indicator ranging from 0 to 1 that reveals how closely the estimated values for the trendline

Table 1. Statistical comparison of nitrate concentrations in the same 43 wells sampled in 2001, 2002, and 2003.

Nitrate Concentrations (mg/L) and Statistics	2001	2002	2003
	Number of Wells (% of wells)	Number of Wells (% of wells)	Number of Wells (% of wells)
0.0 to 2.0	7 (16.2%)	8 (18.6%)	7 (16.3%)
2.0 to 5.0	11 (25.6%)	16 (37.2%)	17 (39.5%)
5.0 to 10.0	23 (53.5%)	17 (39.5%)	18 (41.9%)
> 10.0	2 (4.7%)	2 (4.7%)	1 (2.3%)
Total	43 (100%)	43 (100%)	43 (100%)
Mean Value (mg/L)	5.3	4.5	4.7
Median Value (mg/L)	5.4	4.5	4.7
Maximum Value (mg/L)	10.6	10.0	10.0

(a)



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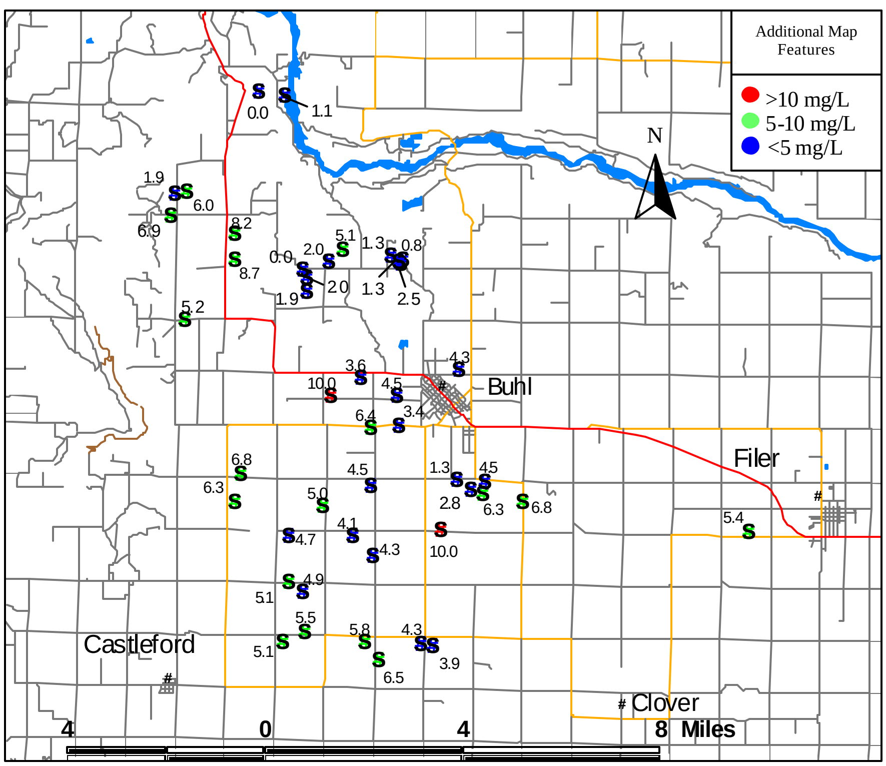

Figure 5. Nitrate concentrations in (a) August 2001 in 54 wells, (b) August 2002 in 45 wells, and (c) August 2003 in 47 wells.

(c)

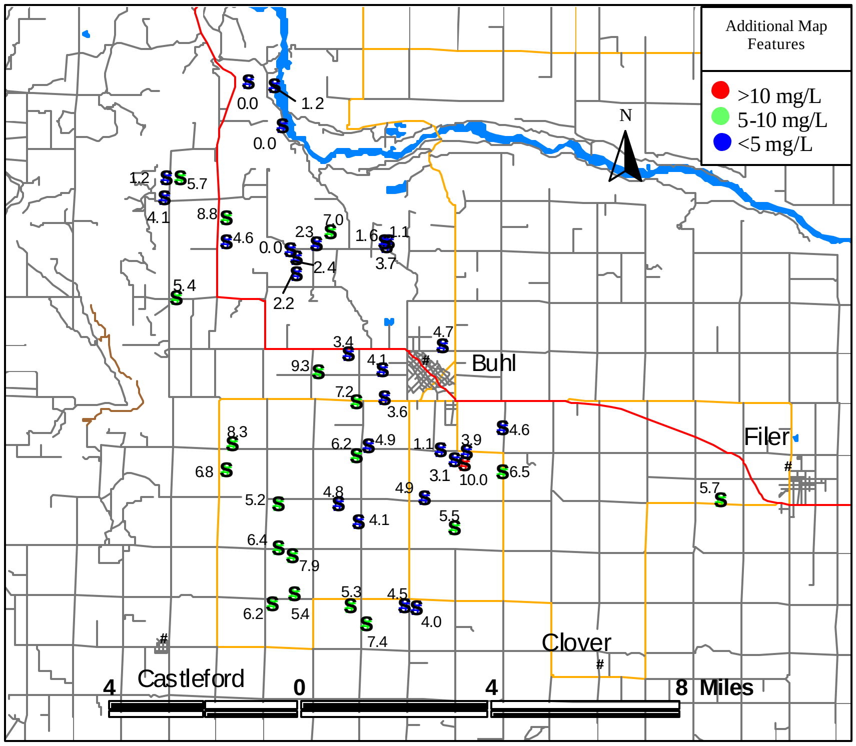

Figure 5. Nitrate concentrations in (a) August 2001 in 54 wells, (b) August 2002 in 45 wells, and (c) August 2003 in 47 wells.

Table 2. Statistical comparison of nitrate concentrations at the same 24 dairies sampled in 2001, 2002, and 2003.

Nitrate Concentrations (mg/L) and Statistics	2001	2002	2003
	Number of Dairy Wells (% of wells)	Number of Dairy Wells (% of wells)	Number of Dairy Wells (% of wells)
0.0 to 2.0	1 (4.2%)	1 (4.2%)	1 (4.2%)
2.0 to 5.0	5 (20.8%)	10 (41.7%)	9 (37.5%)
5.0 to 10.0	17 (70.8%)	11 (45.8%)	14 (58.3%)
> 10.0	1 (4.2%)	2 (8.3%)	0 (0%)
Total	24 (100%)	24 (100%)	24 (100%)
Mean Value (mg/L)	6.3	5.5	5.6
Median Value (mg/L)	6.4	5.1	5.4
Maximum Value (mg/L)	10.6	10.0	9.3

Table 3. Statistical comparison of nitrate concentrations at the same 19 domestic wells sampled in 2001, 2002, and 2003.

Nitrate Concentrations (mg/L) and Statistics	2001	2002	2003
	Number of Domestic Wells (% of wells)	Number of Domestic Wells (% of wells)	Number of Domestic Wells (% of wells)
0.0 to 2.0	6 (31.6%)	7 (36.8%)	6 (31.6%)
2.0 to 5.0	6 (31.6%)	6 (31.6%)	8 (42.1%)
5.0 to 10.0	6 (31.6%)	6 (31.6%)	4 (21.0%)
> 10.0	1 (5.2%)	0 (0%)	1 (5.3%)
Total	19 (100%)	19 (100%)	19 (100%)
Mean Value (mg/L)	4.0	3.3	3.5
Median Value (mg/L)	3.3	2.8	3.4
Maximum Value (mg/L)	10.0	6.9	10.0

(a)

(b)

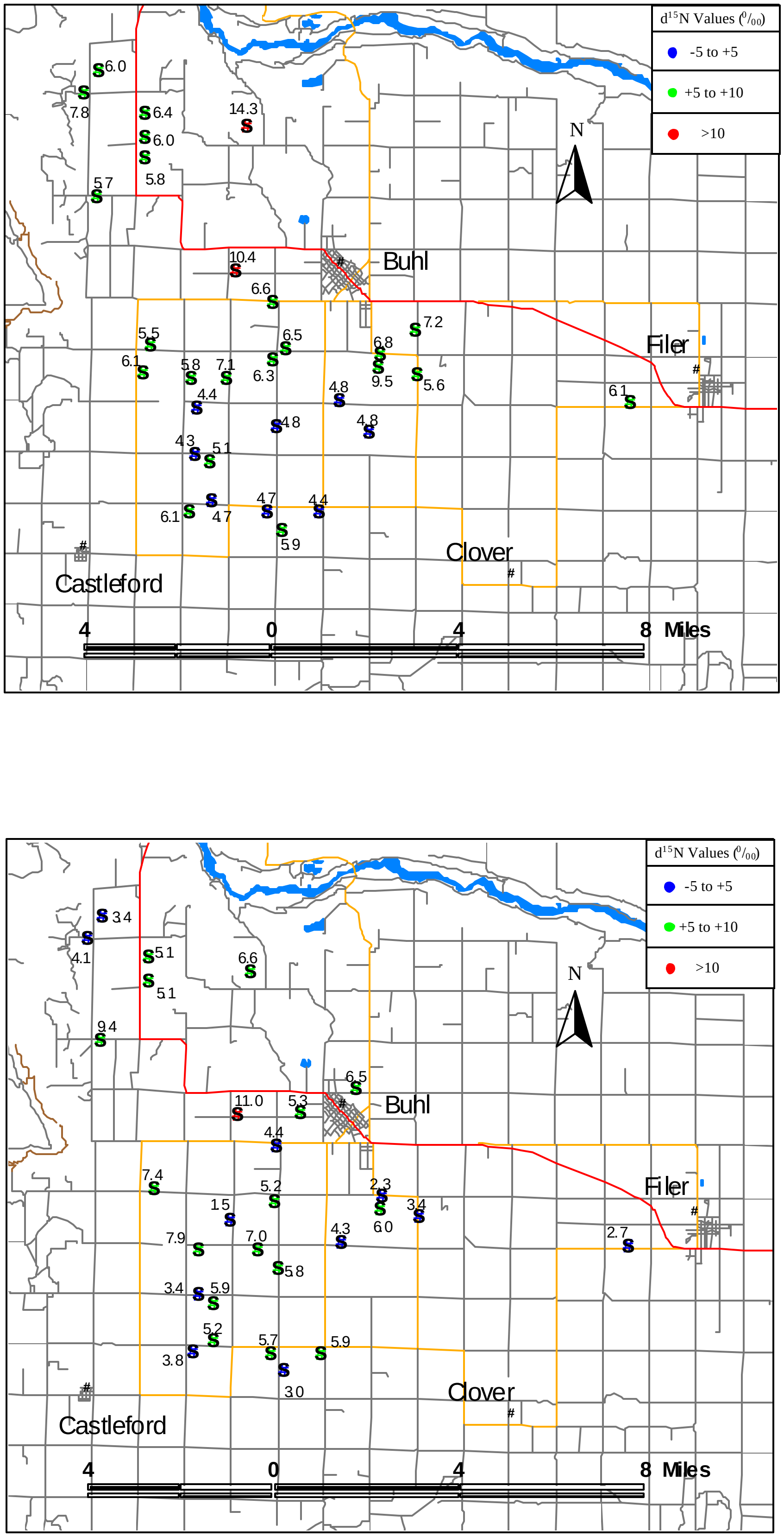

Figure 6. d15N values in (a) August 2001 at 31 wells and (b) August 2002 at 28 wells.

correspond to the actual data. A trendline is most reliable when its R-squared value is at or near one. Therefore, there is no indication that denitrification is occurring.

Conclusions

Ground water within the basalt aquifer of the project area is being impacted from nitrates. Median nitrate concentrations have not exhibited large changes over time; however, the percentage of wells over 5 mg/L has decreased from 58.2% in 2001 to 44.2% in 2003. Agricultural practices likely contribute to the NO_3-N detections in the ground water of this project area. The large number of $d^{15}N$ values below 5 $^{0}/_{00}$ suggests that fertilizer sources are contributing to elevated NO_3-N concentrations. Other potential sources include the leaching of animal wastes, legume crops, and septic systems.

The median nitrate value for dairy wells has been higher than that of domestic wells each year of the study. However, the median nitrate value at the same dairy wells tested in all three years decreased from 6.4 mg/L in 2001 to 5.1 mg/L in 2002; a slight increase occurred from 2002 (5.1 mg/L) to 2003 (5.4 mg/L). Additionally, from 2001 to 2002, the percentage of dairy wells in the 5 to 10 mg/L nitrate range dropped from 70.8% to 45.8% while the percentage in the 2 to 5 mg/L range increased from 20.8% to 41.7%. The percentage of dairy wells in the 5 to 10 mg/L range increased from 45.8% to 58.3% between 2002 and 2003. Potentially the largest contributing factor in the reduction of nitrate values at dairies from 2001 to 2002 was the development of nutrient management plans by July 1, 2001.

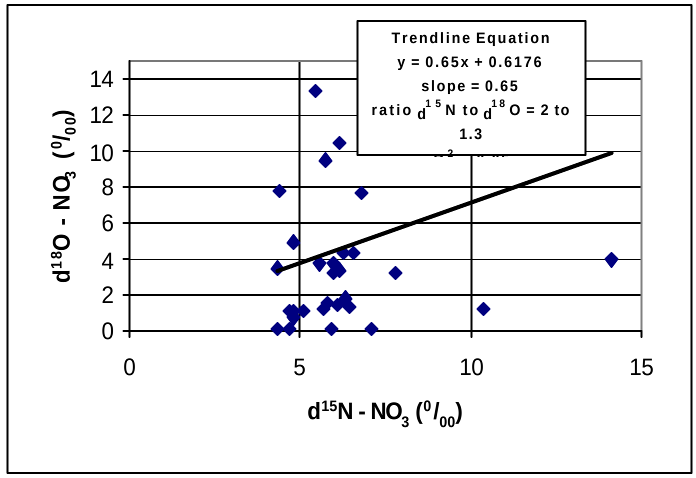

Figure 7. Plot of $d^{18}O$ versus $d^{15}N$ for 31 wells in 2001 in the Buhl area.

Recommendations

To determine if current farming practices are contributing to ground water degradation and to locate other potential contaminant sources, the ISDA recommends continued monitoring in the project area and evaluation of the dairies individually.

Testing may include, but not be limited to:

- Continued ground water monitoring for nutrients and common ions.
- Continued nitrogen isotope testing to determine possible nitrate sources and relative ages of ground water.
- Soil sampling and soil pore water sampling.
- Antibiotic and hormone testing of ground water to determine potential human and animal waste sources.

Table 4. $d^{15}N$ results for Buhl area dairy nitrate monitoring project, 2001-2003.

$d^{15}N$ Values ($^{0}/_{00}$)	Potential Contaminant Source	2001 Number of wells (% of wells)	2002 Number of wells (% of wells)
-5 to +5	Commercial Fertilizer	8 (25.8%)	11 (39.3%)
+5 to +10	Organic Nitrogen in Soil	21 (67.7%)	16 (57.1%)
>10	Animal or Human Waste	2 (6.5%)	1 (3.6%)

ISDA further recommends that measures to reduce nitrate impacts on ground water be addressed and implemented. ISDA recommends that:

- Growers and agrichemical professionals conduct nutrient and irrigation water management evaluations.
- Producers follow the Idaho Agricultural Pollution Abatement Plan and Natural Resources Conservation Service Nutrient Management Standard.
- Homeowners assess lawn and garden practices, especially near wellheads.
- Local residents assess animal waste management practices.
- State and local agencies assess impacts from private septic systems.
- Home and garden retail stores establish outreach programs to illustrate proper application and management of nutrients.
- Dairy facilities and records be further evaluated for pollution prevention.

ISDA recommends that the Balanced Rock Soil Conservation District lead a response process to create a plan of action to address these ground water contamination issues. The soil and water conservation district, SCC, and ISDA should work with local agrichemical professionals, landowners, and agencies to implement this process and seek funding to support these efforts. ISDA will support these local partners in seeking funding and implementing a comprehensive program. ISDA will be working with the DEQ led Twin Falls Nitrate Committee in creating a plan for nitrate response.

References

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